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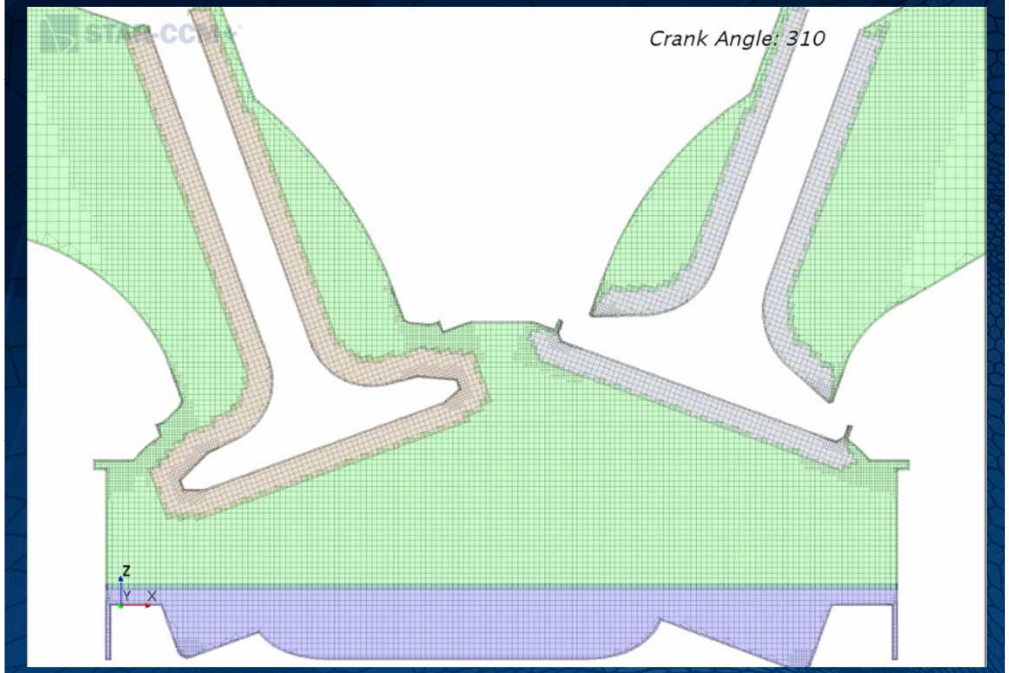
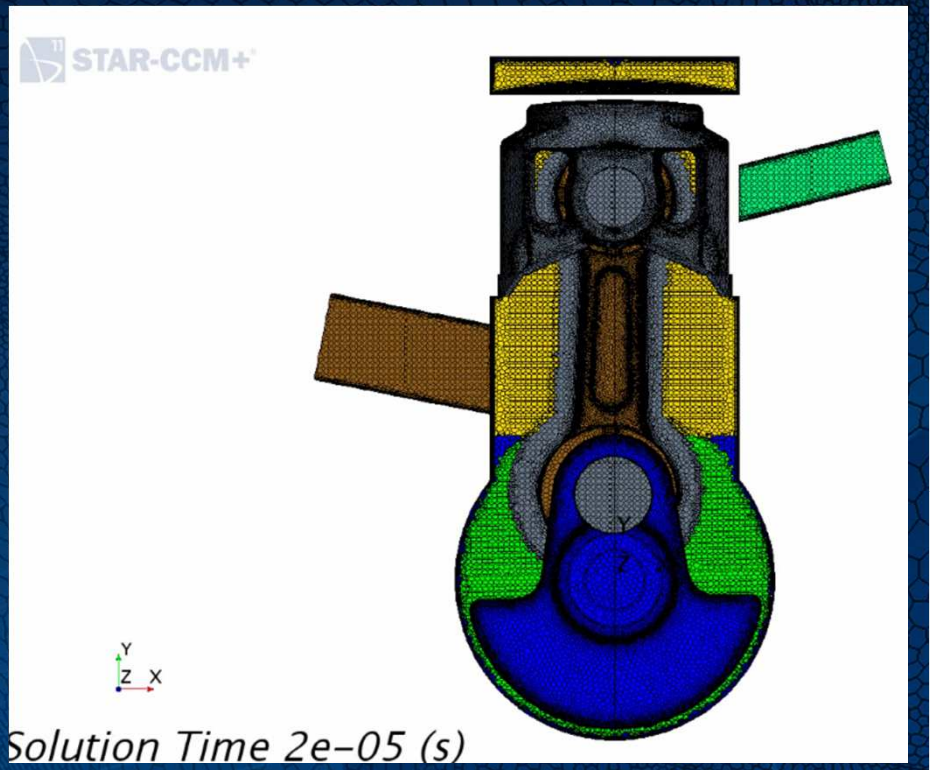




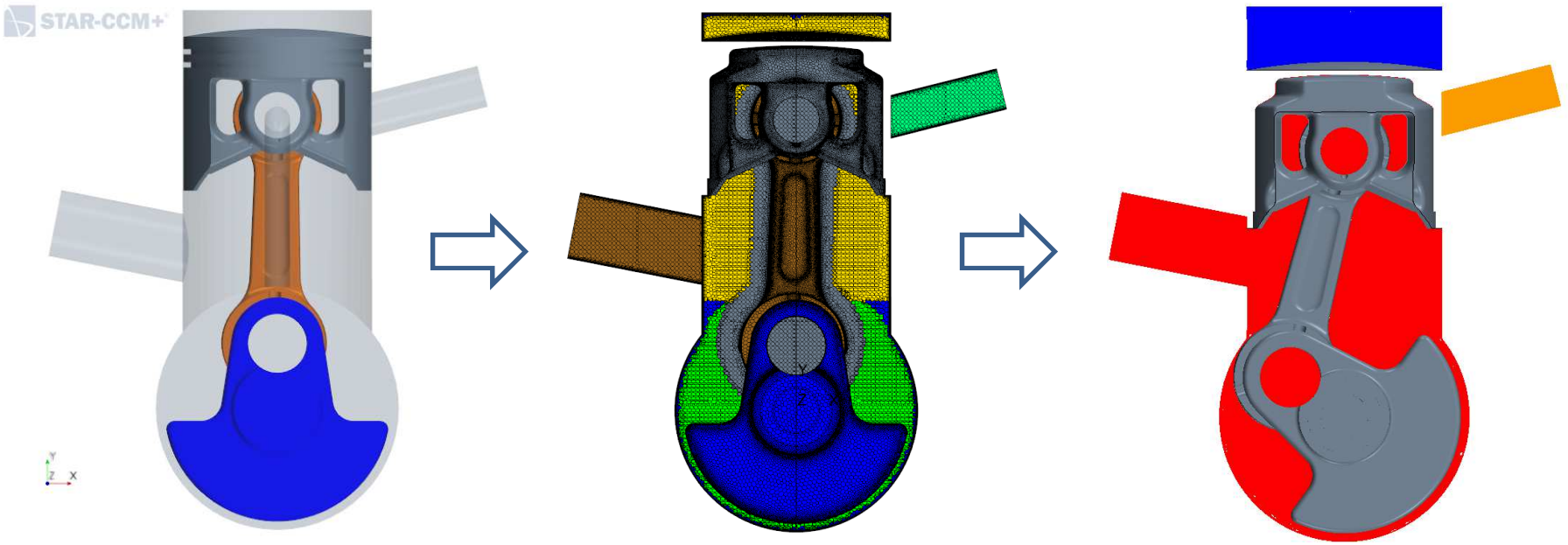
Overset mesh for Internal Combustion Engine Simulation in STAR-CCM+

Daniel Uhlmann, Eberhard Schreck

Outline

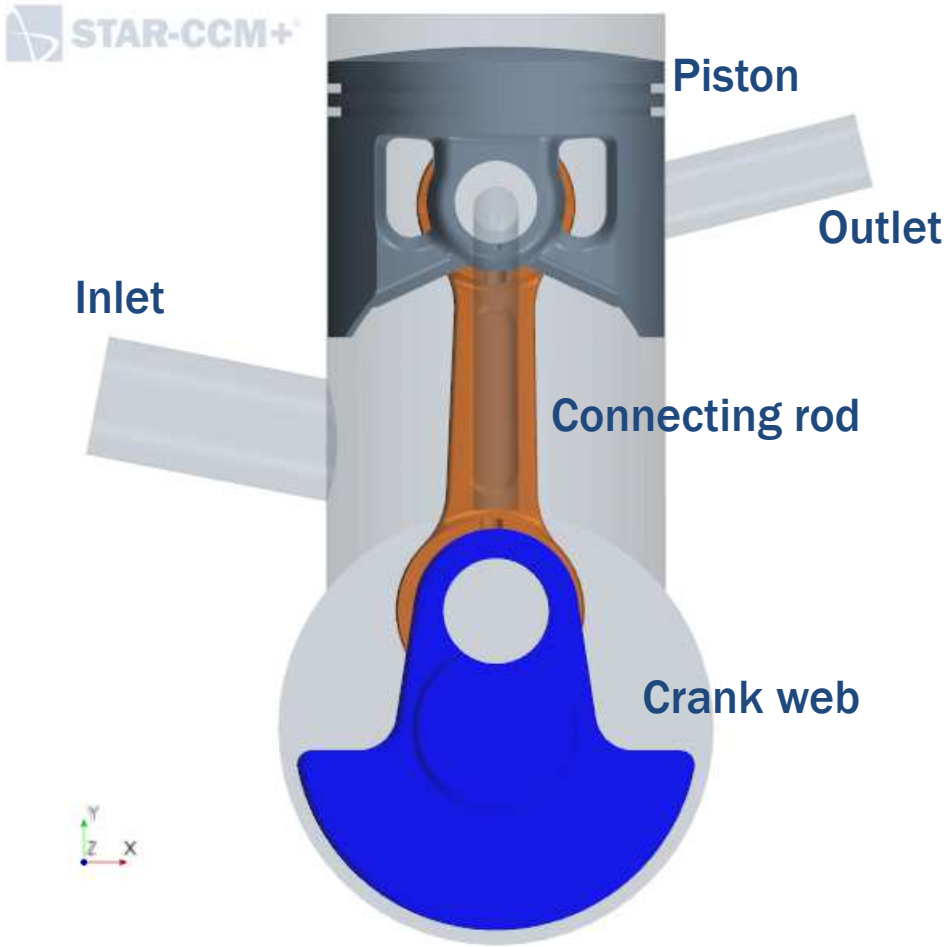
- **Two-stroke engine regular Overset interface**
  - Geometry
  - Regions
  - Interface setup
  - Mesh
  - Physics
  - Overset features
  - Post-processing
- **Two-stroke engine with Overset ZeroGap approach**
  - Regions
  - Interface setup
  - Mesh and Physics
  - Post-processing
- **Pro/Con Overset vs Overset ZeroGap for two-stroke engines**
- **Four-stroke engine with Overset ZeroGap approach**
  - Geometry
  - Regions
  - Interface setup
  - Mesh
  - Physics
  - Overset features
  - Post-Processing

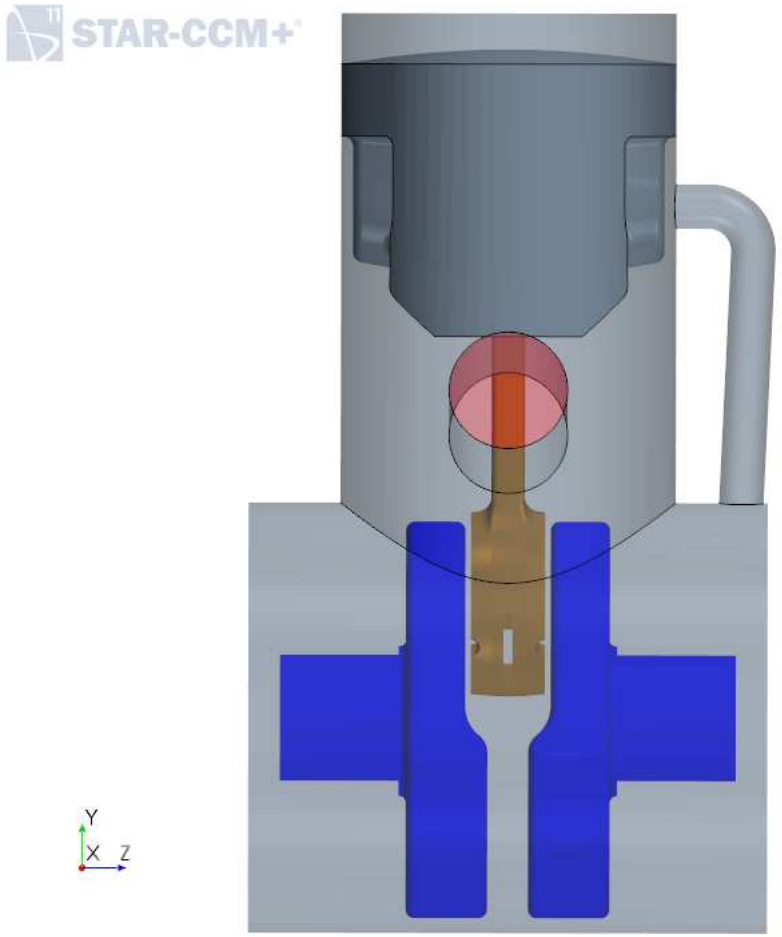
Two-stroke engine regular Overset interface



Geometry

- Piston, connecting rod and crank web were taken from GrabCAD*. The crankcase was built in STAR-CCM+ 3D CAD.

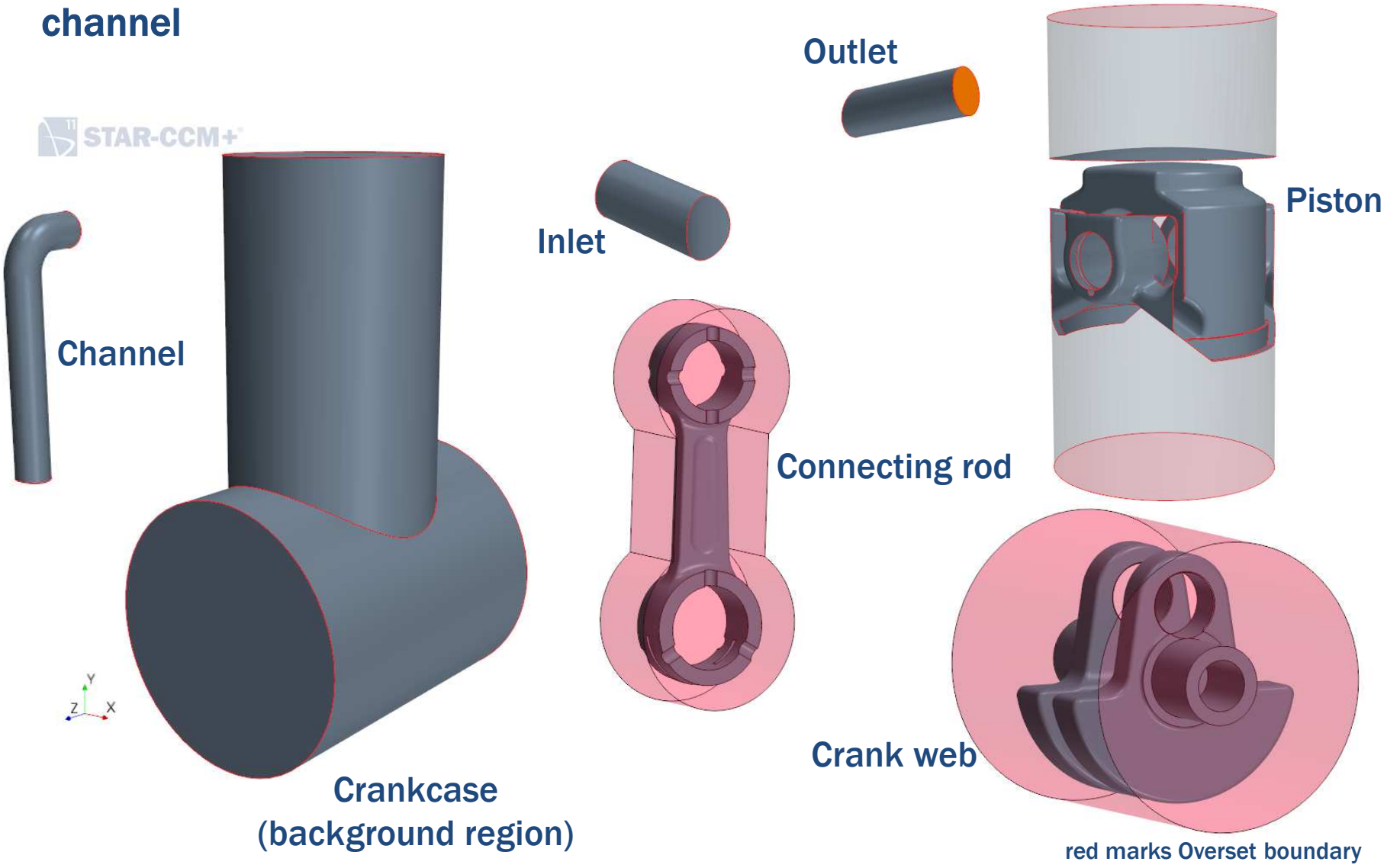




*https://grabcad.com/library/two-stroke-slider-crank-mechanism

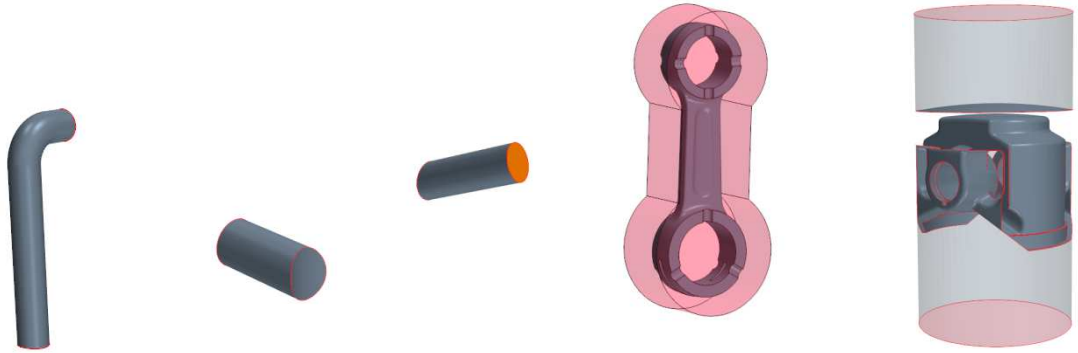
Regions

- 7 regions: piston, connecting rod, crank web, crankcase, inlet, outlet, channel

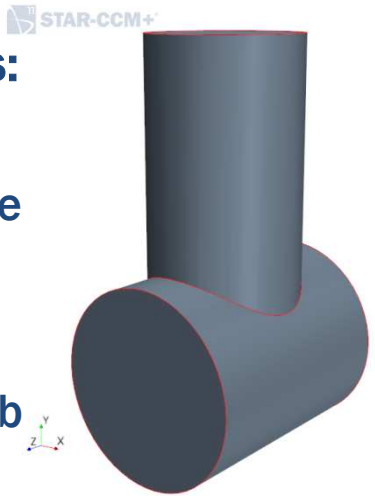


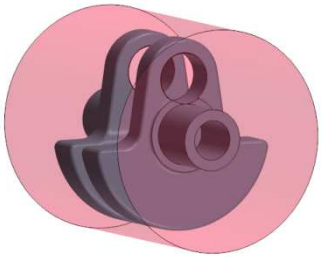
Interface setup

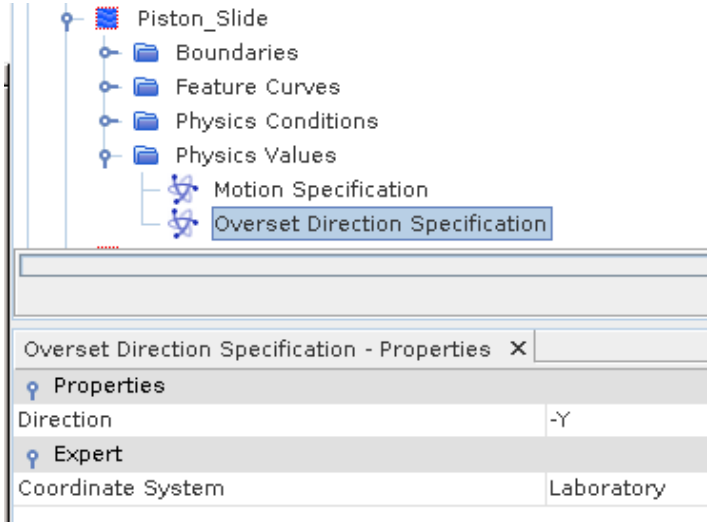
- **4 boundary interfaces:**
  - channel – crankcase
  - inlet – piston
  - outlet – piston
  - channel – piston



- **6 regular Overset interfaces:**
  - piston – crankcase
  - connecting rod – crankcase
  - crank web – crankcase
  - piston– crank web
  - connecting rod – crank web
  - connecting rod – piston



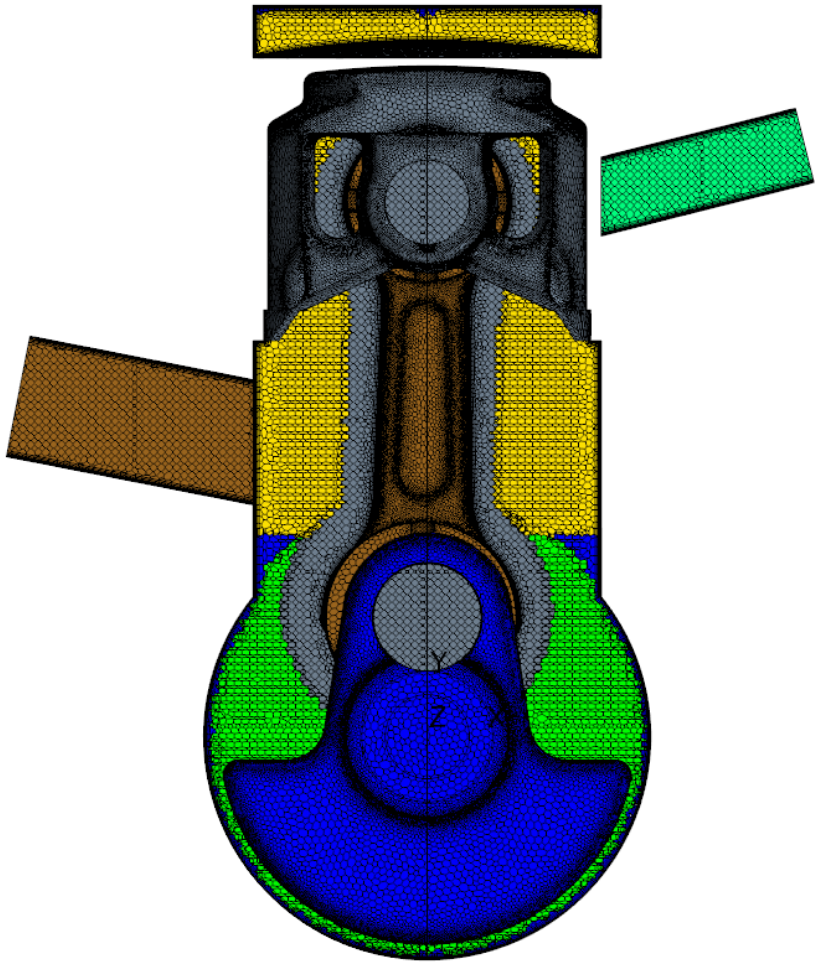


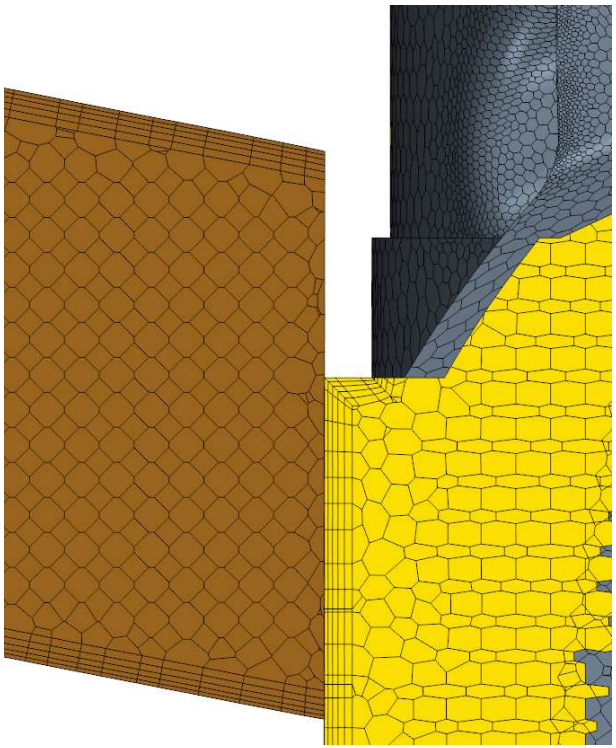


Overset topology - Direction: for applications where the Overset boundary does not completely enclose the overset region

Mesh

- 2.9m poly cells
- 5 prism layers

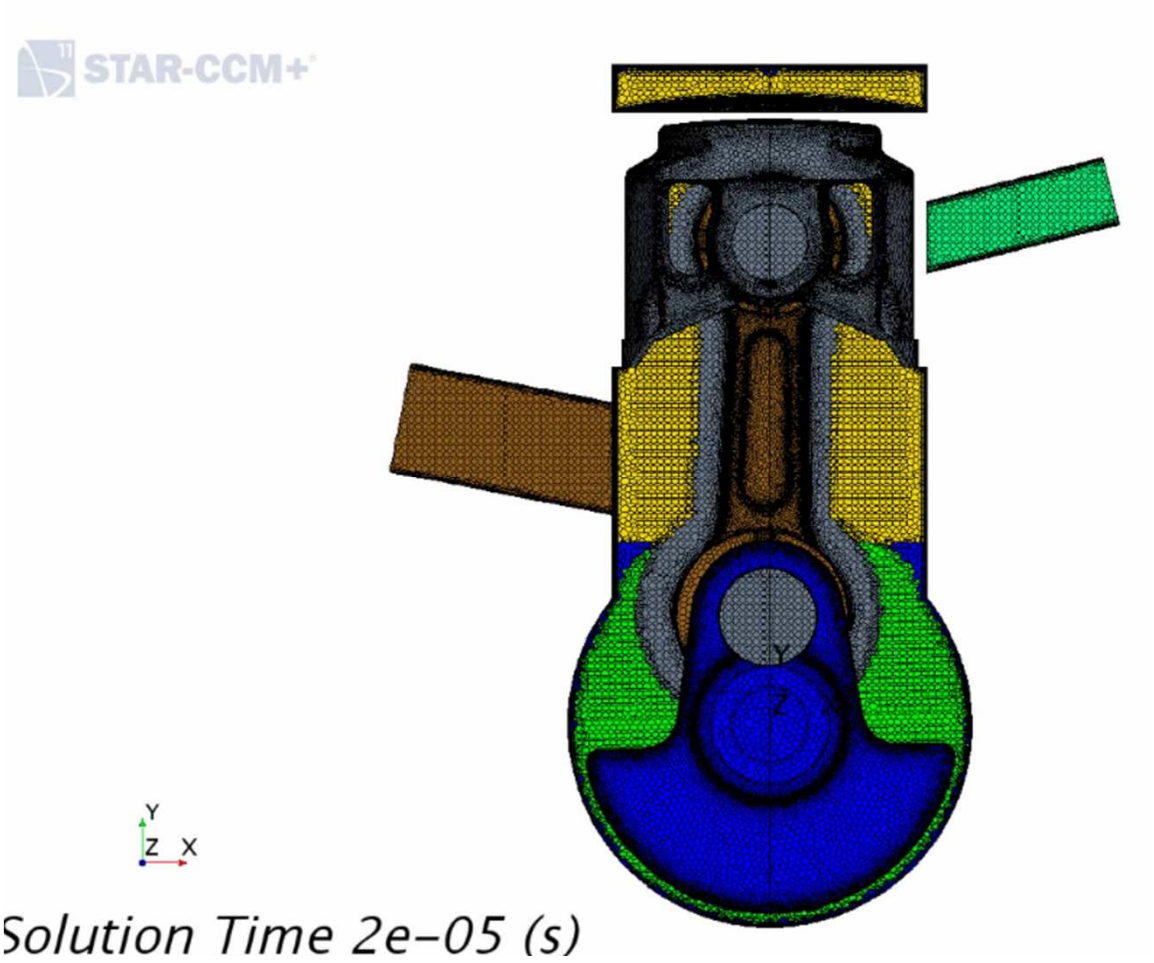




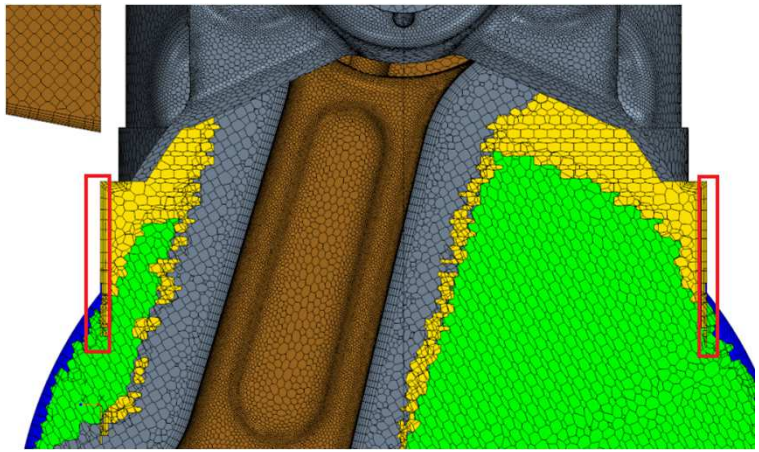
Exact opening and closing time for the inlet and outlet flow

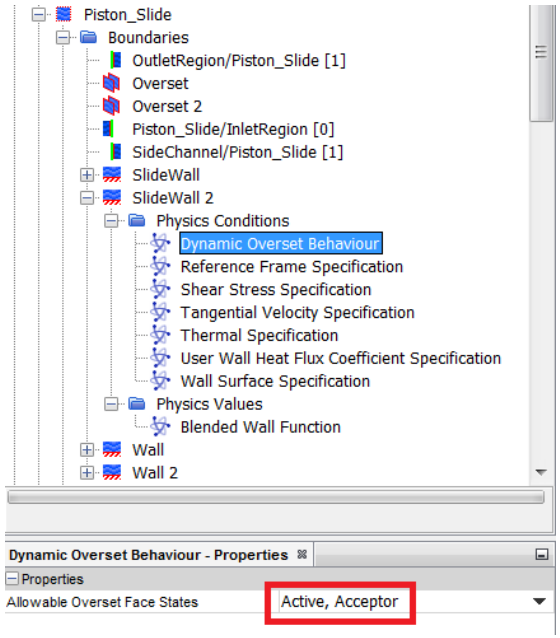
Mesh

Mesh motion



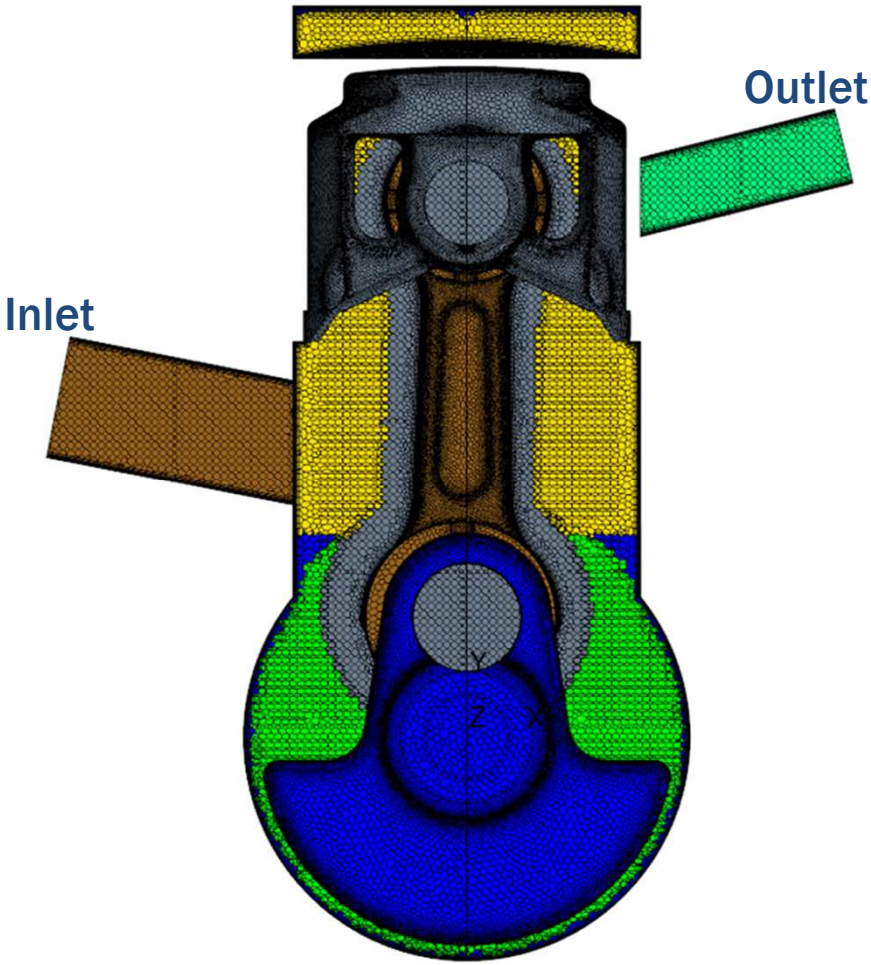
Dynamic Overset Behaviour





Physics

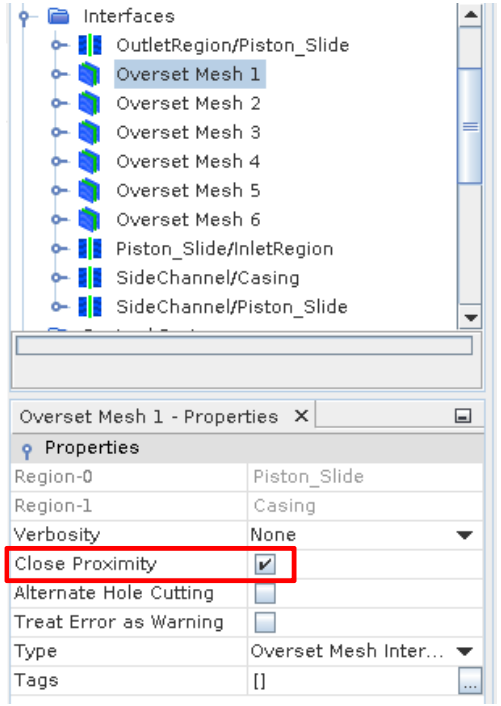
- **Physics**
  - Implicit unsteady
  - Ideal gas
  - Segregated flow solver
  - Realizable k-epsilon two-layer
- **Boundaries**
  - Stagnation inlet = 0Pa (unrealistic)
  - Pressure outlet = 0Pa (unrealistic)
- **Motion**
  - Crankweb: rotation 10,000rpm
  - Piston: translation
  - Connecting rod: superposing rotation
- **Overset interfaces**
  - Close proximity enabled
  - Interpolation: linear

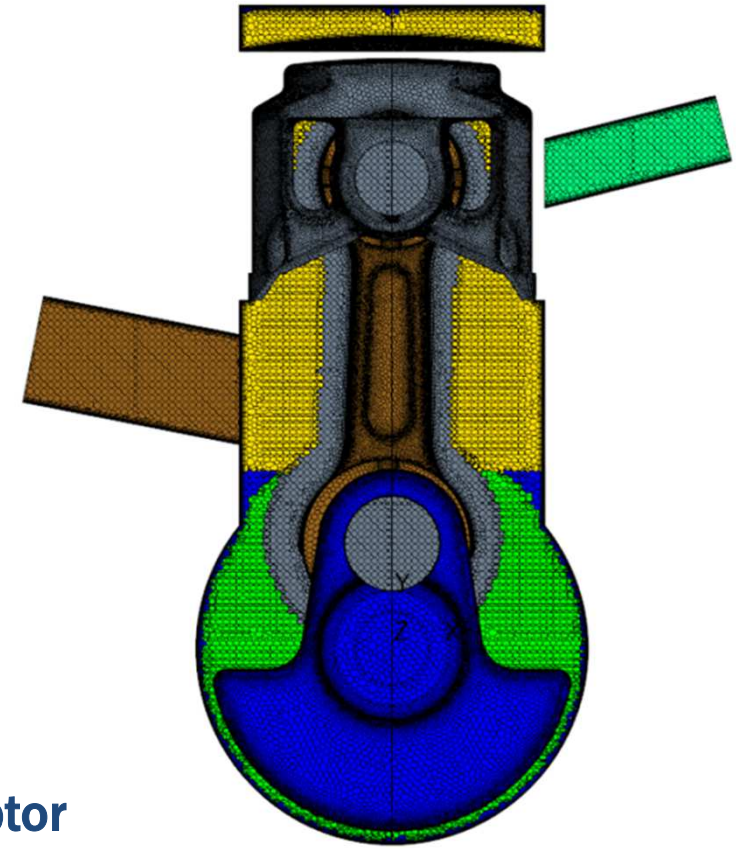


Overset features

Close Proximity

- cell is deactivated only when the cell centroid is outside the boundary



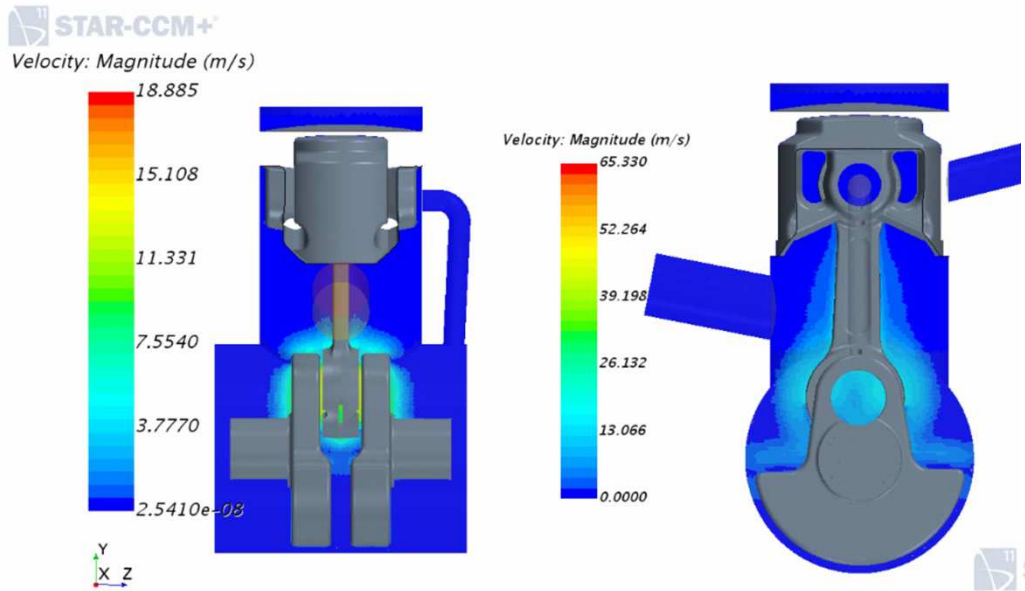


Linear interpolation

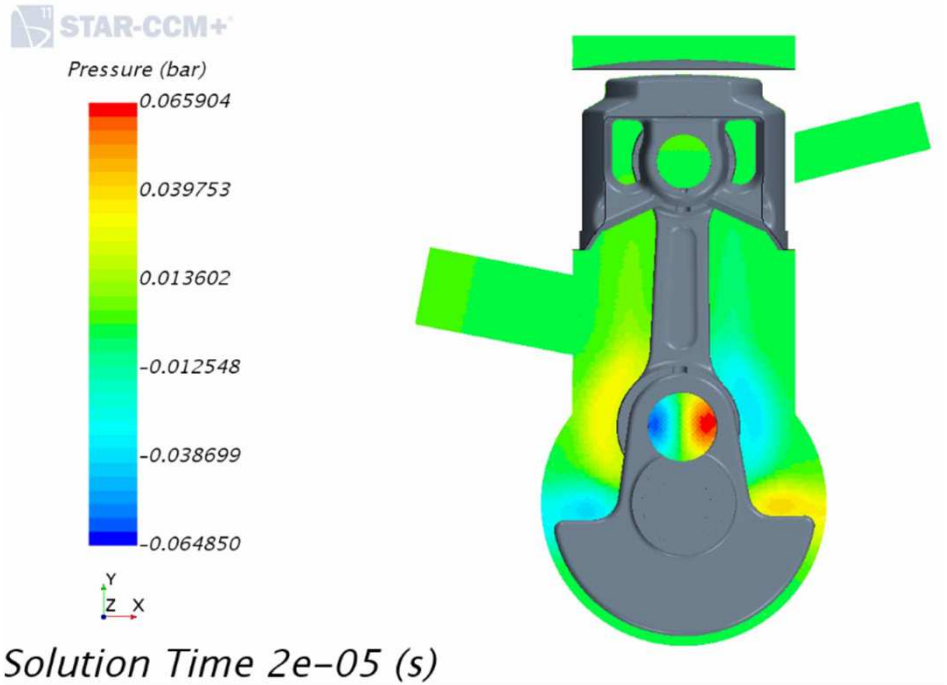
Dynamic Overset Behaviour: Active, Acceptor

Overset topology: Direction

Post-processing



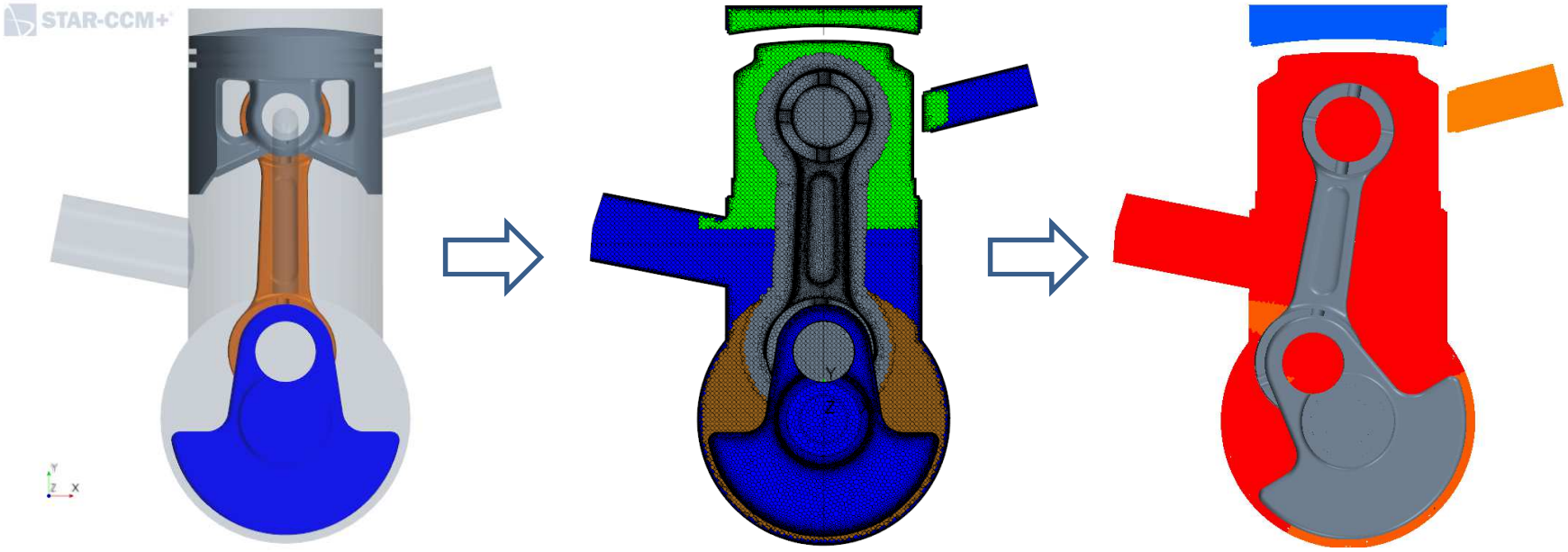
Solution Time 2e-05 (s)



Solution Time 2e-05 (s)

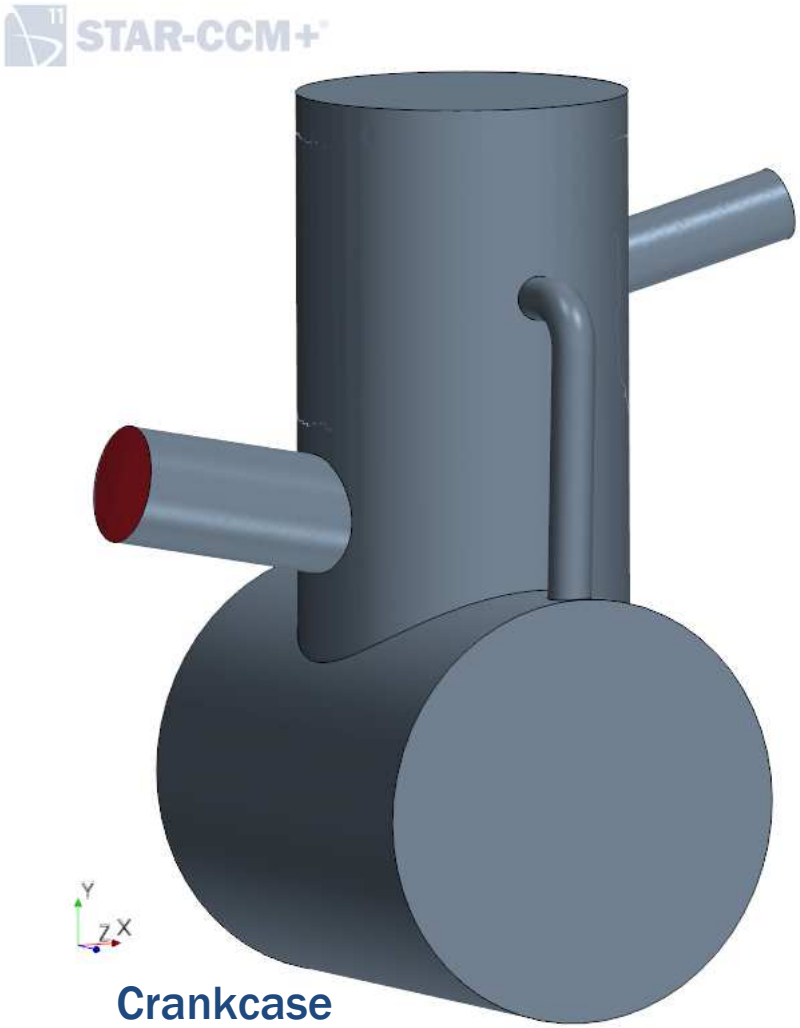
Note: This is a generic geometry. We do not apply realistic boundary conditions.

Two-stroke engine with Overset ZeroGap approach

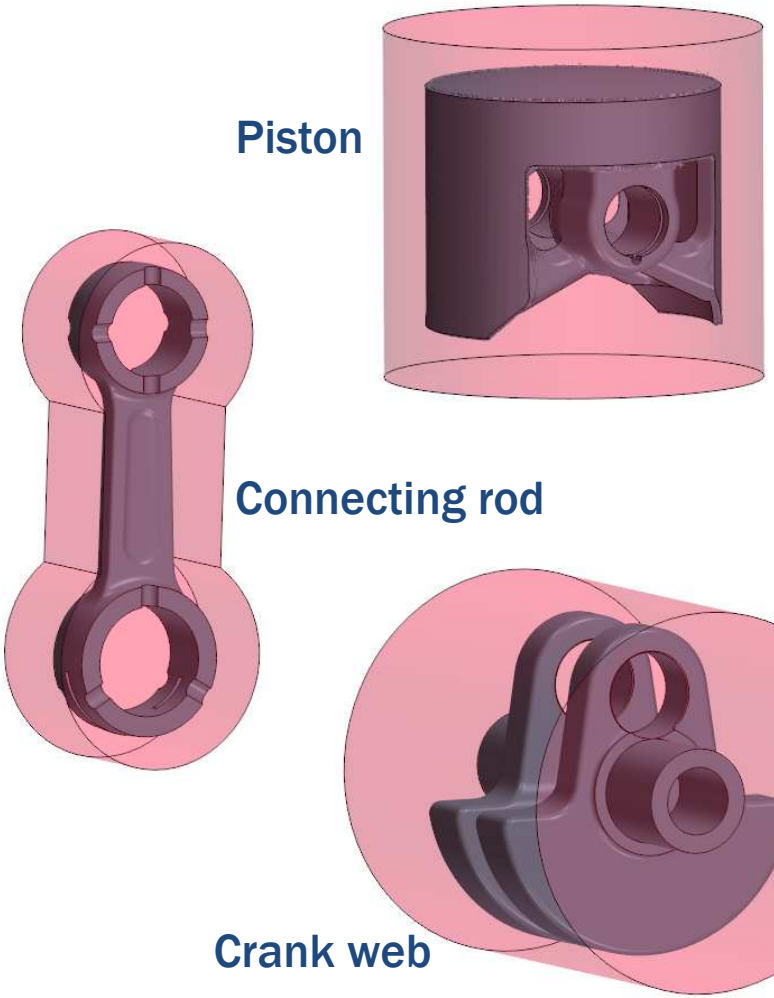


Regions

- 4 regions: piston, connecting rod, crank web, crankcase



Crankcase
(background region)



Piston

Connecting rod

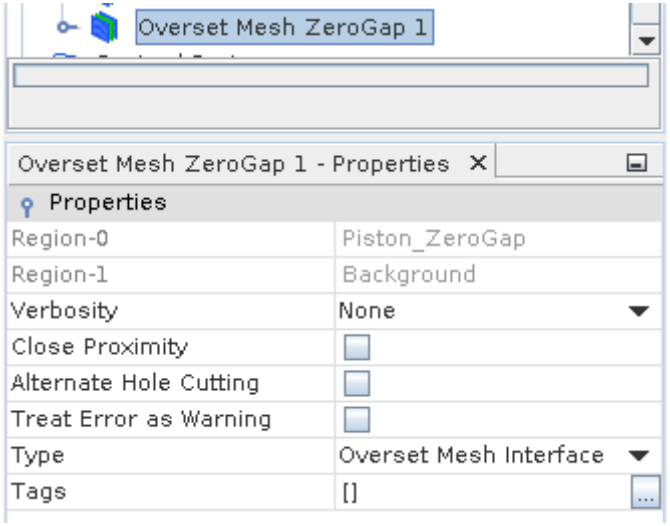
Crank web

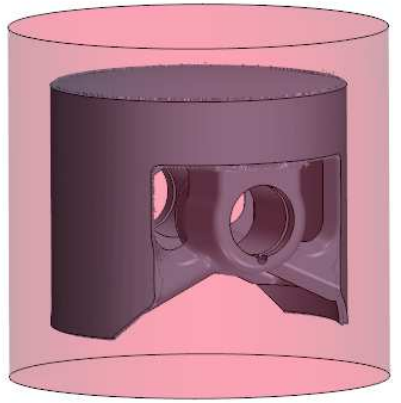
red marks Overset boundary

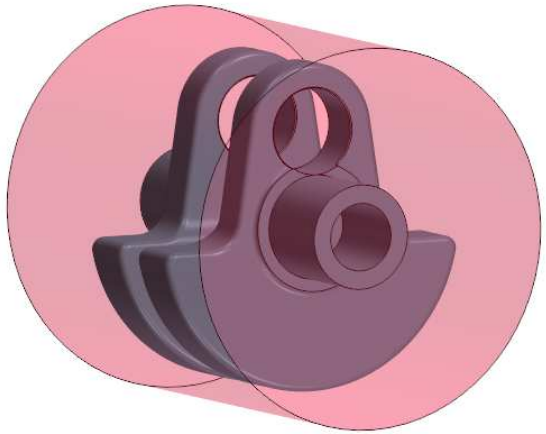
Interface setup

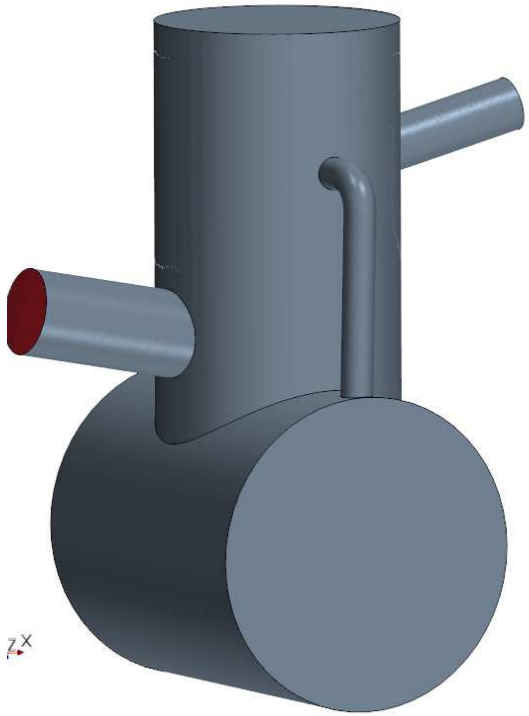
- **1 Overset ZeroGap interface:**
  - piston – crankcase

- **5 regular Overset interfaces:**
  - connecting rod – crankcase
  - crank web – crankcase
  - piston– crank web
  - connecting rod – crank web
  - connecting rod – piston



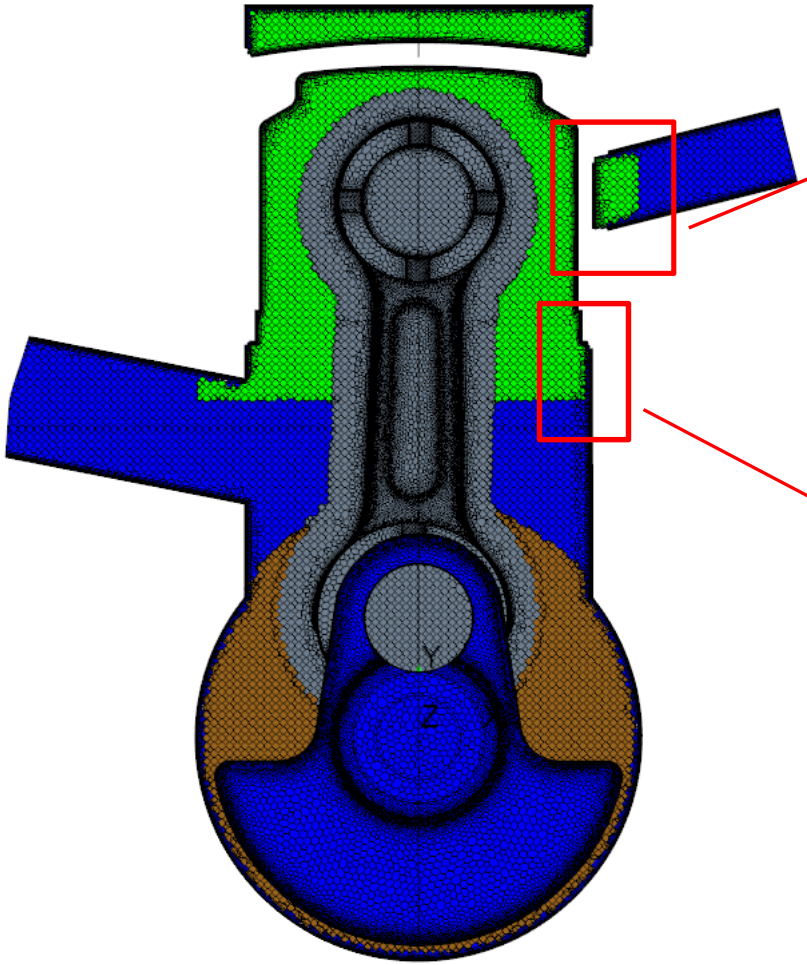






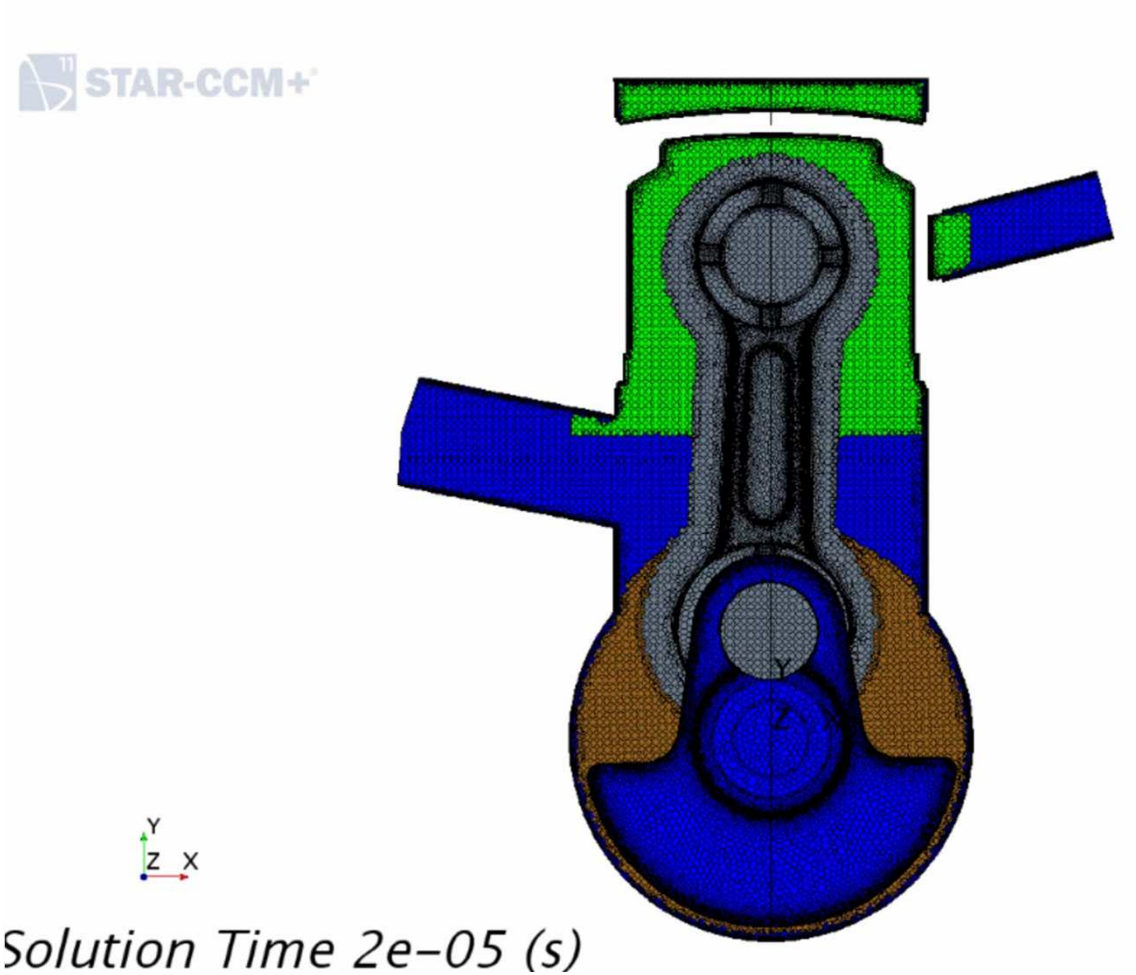
Mesh and Physics

- 3.3m poly cells
- 5 prism layers



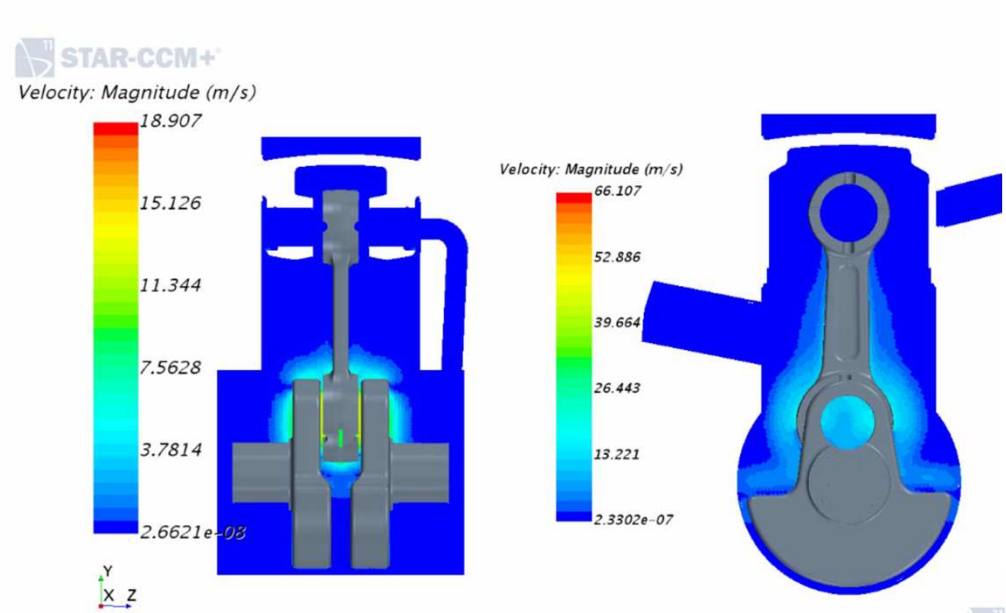
ZeroGap walls can have an influence on the opening and closing time for the inlet and outlet flow

Mesh and Physics

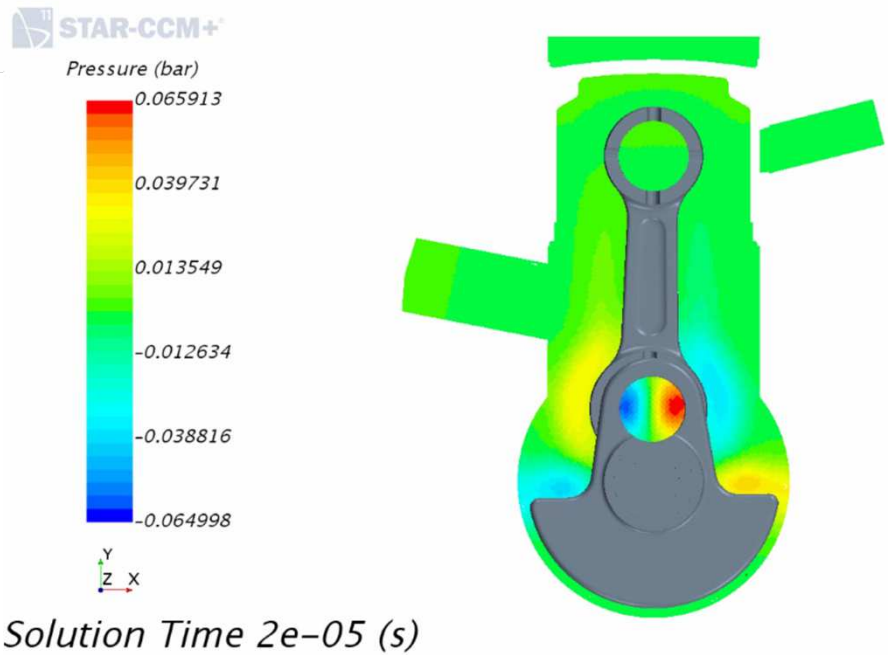


- Physics are identical to the previous case

Post-processing



Solution Time 2e-05 (s)

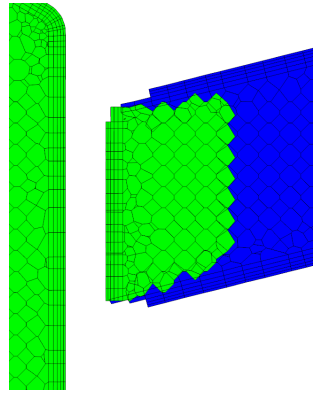


Solution Time 2e-05 (s)

Note: This is a generic geometry. We do not apply realistic boundary conditions.

Pro/Con Overset vs Overset ZeroGap

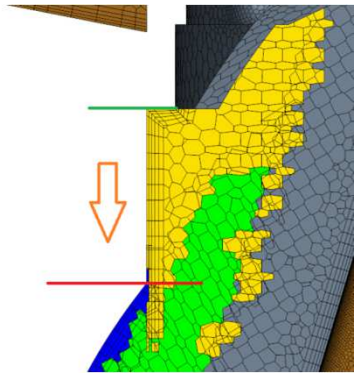
- **Pro Overset ZeroGap:**
  - Less interfaces
  - Piston-crankcase penetration allowed



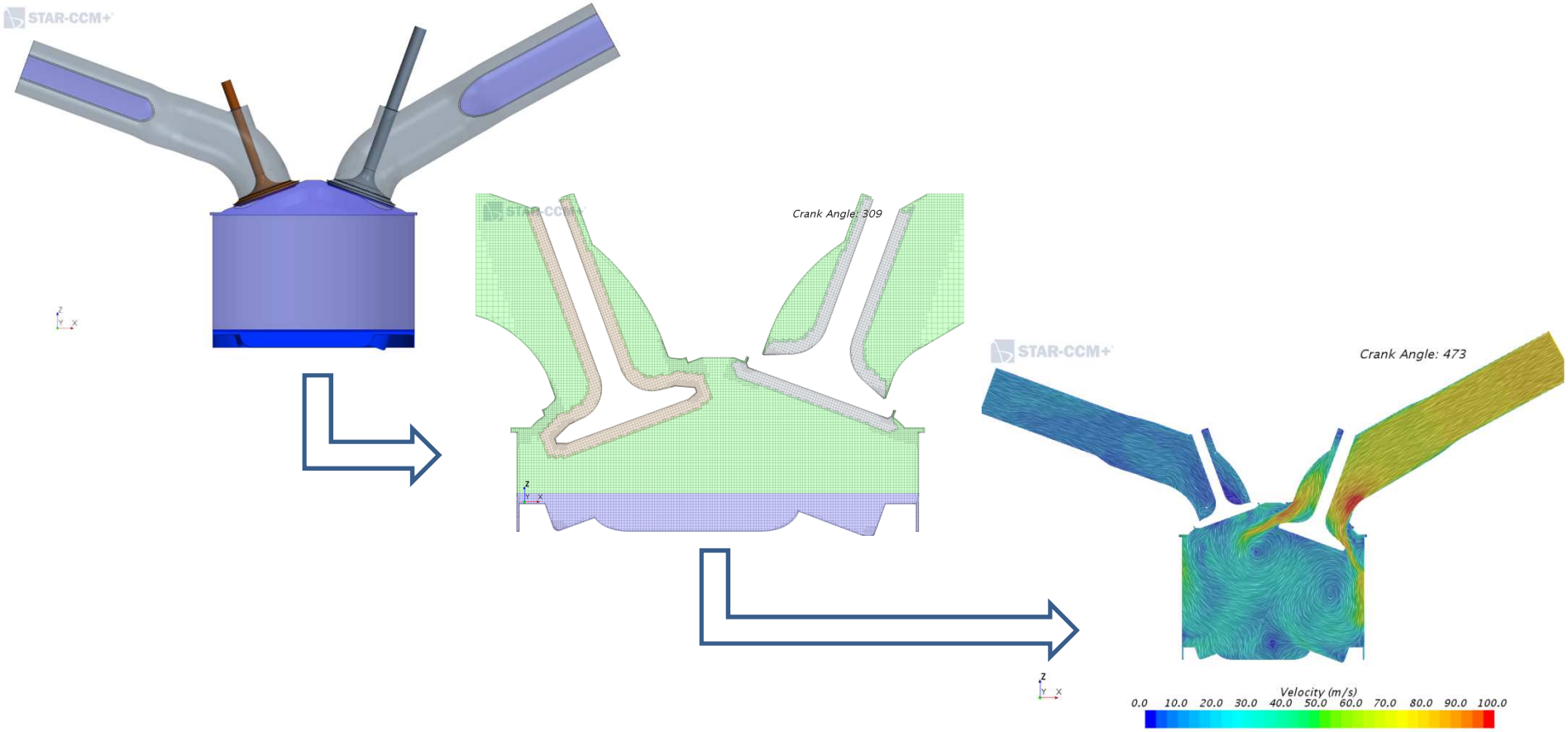
- **Con Overset ZeroGap:**
  - Incorrect opening and closing time of the inlet and outlet
  - More cells required

- **Pro regular Overset interface:**
  - Correct opening and closing time of the inlet and outlet
  - Less cells required

- **Con regular Overset interface:**
  - More interfaces
  - Piston-crankcase penetration not possible

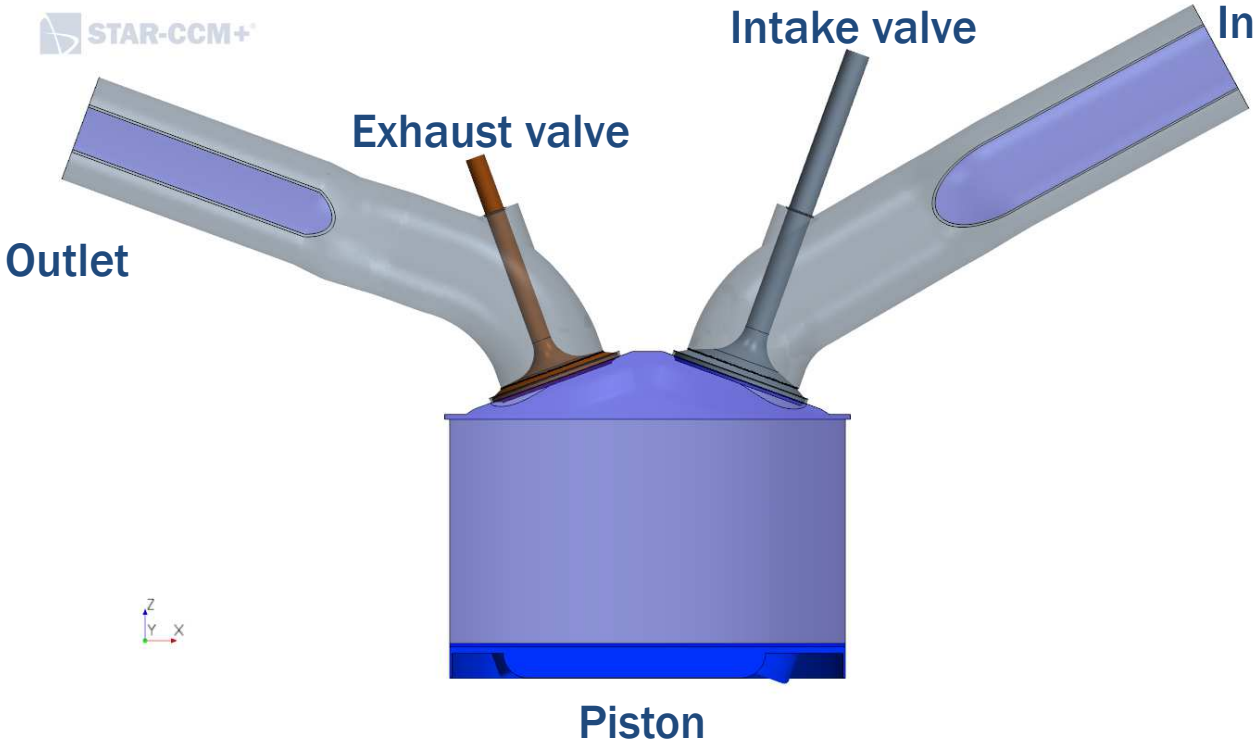


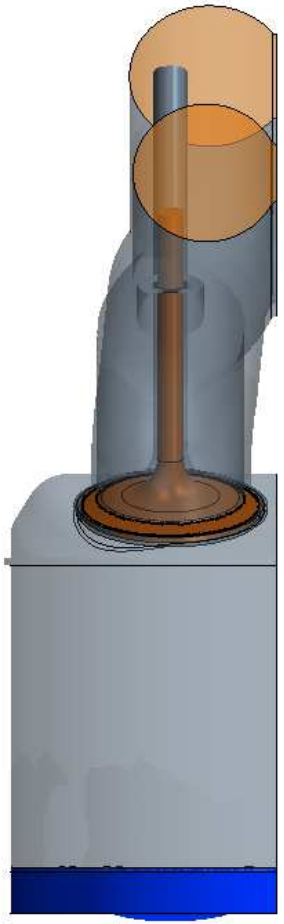
Four-stroke engine with Overset ZeroGap approach



Geometry

Generic 4-stroke geometry*

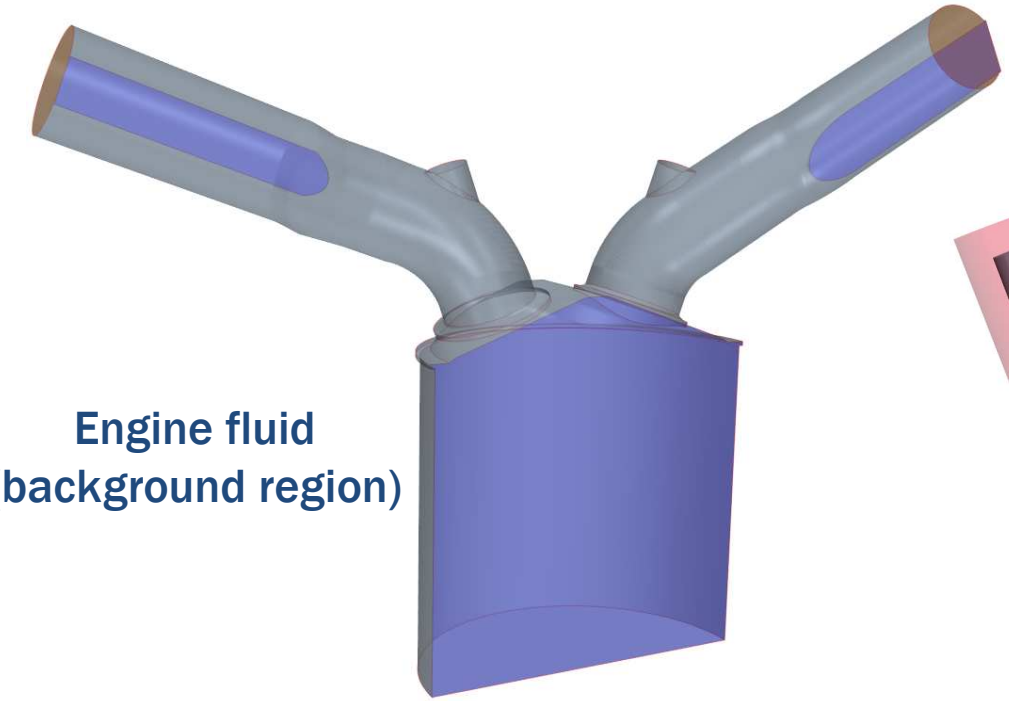




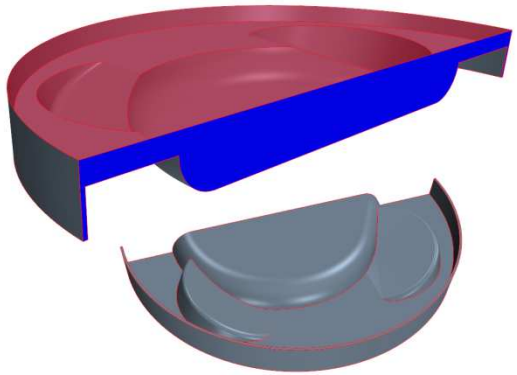
*Courtesy of Simon Fischer, CD-adapco

Regions

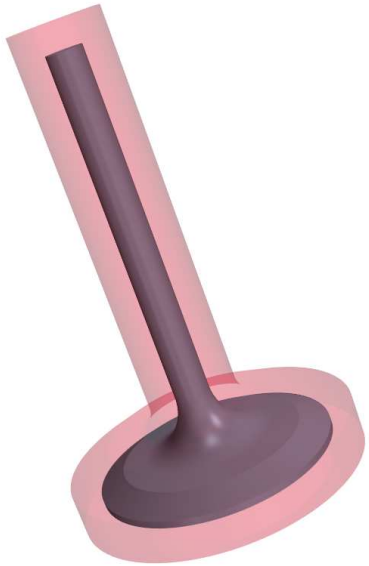
- 4 regions: piston, engine, exhaust valve, intake valve



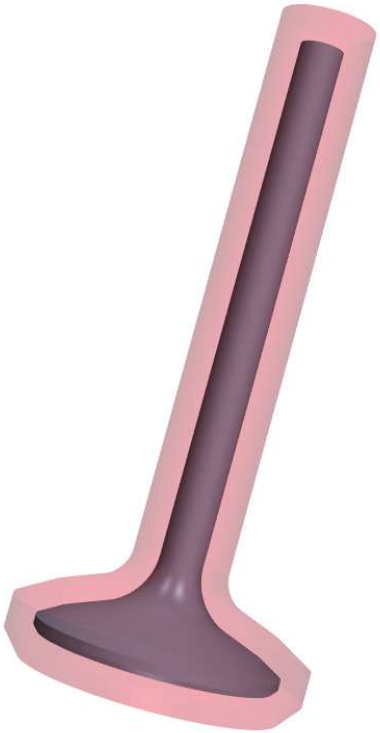
Engine fluid
(background region)



Piston



Exhaust valve



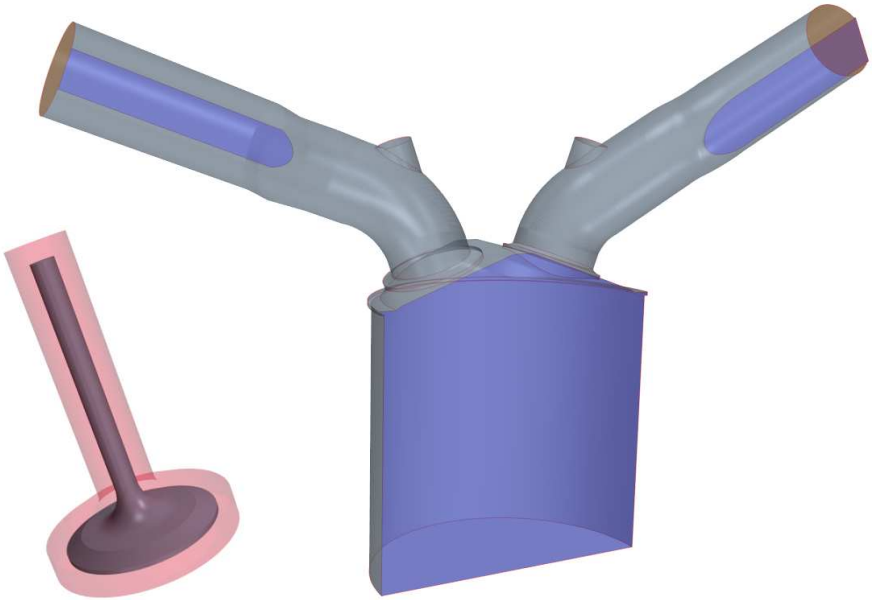
Intake valve

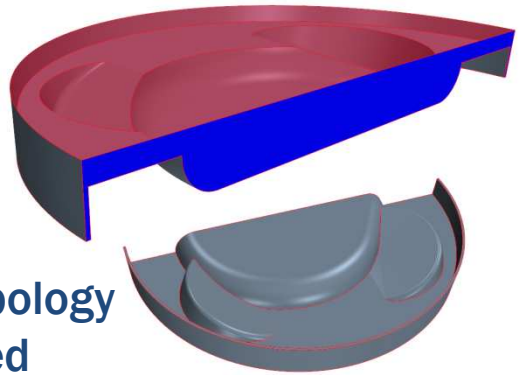
red marks Overset boundary

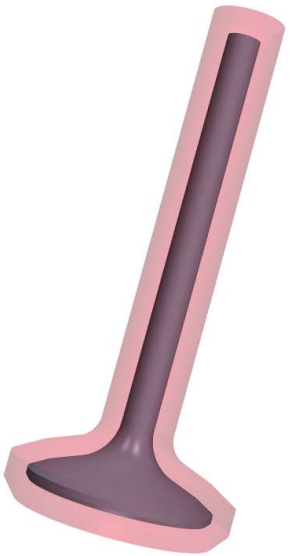
Interface setup

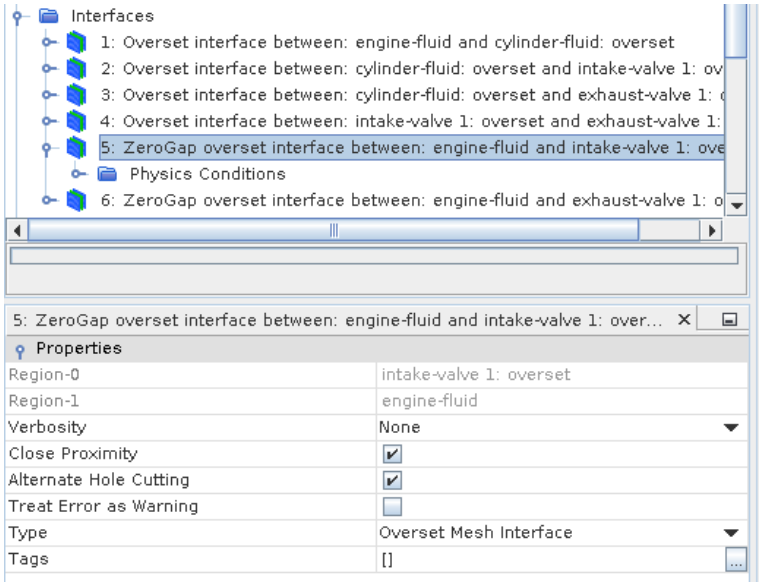
- **4 regular Overset interfaces:**
  - engine fluid - piston
  - piston – intake valve
  - piston – exhaust valve
  - intake valve – exhaust valve

- **2 Overset ZeroGap interfaces:**
  - engine fluid – intake valve
  - engine fluid – exhaust valve





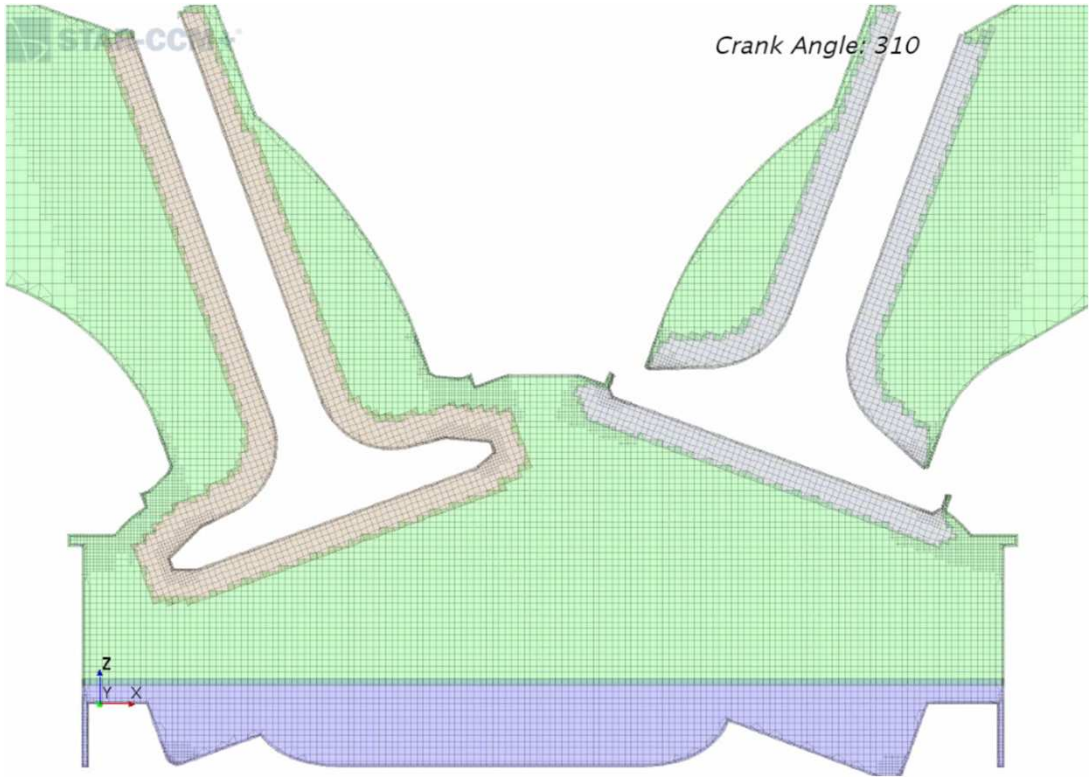


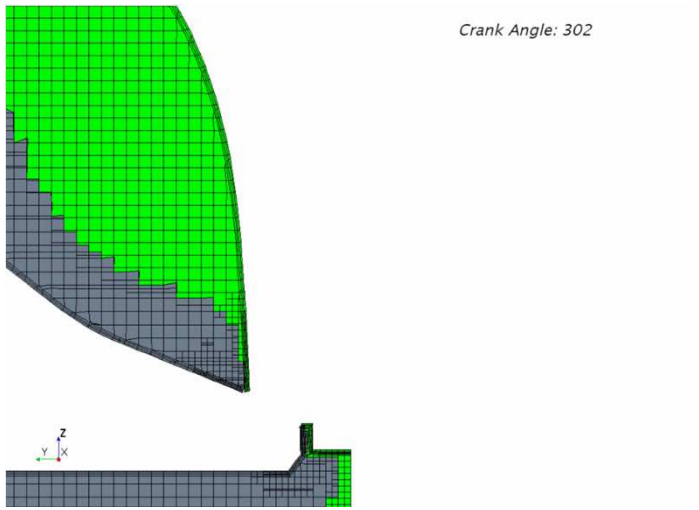


Piston topology is used

Mesh

- 3.6m cells
- 5 prism layers in ZeroGap area (otherwise 3 prism layers)

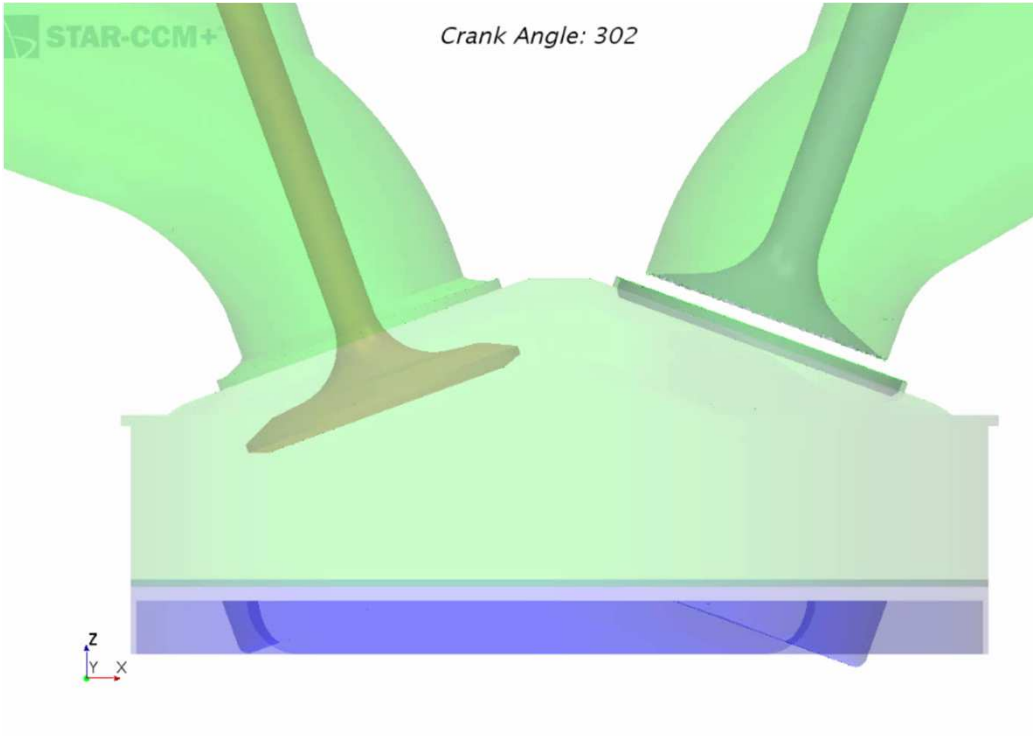


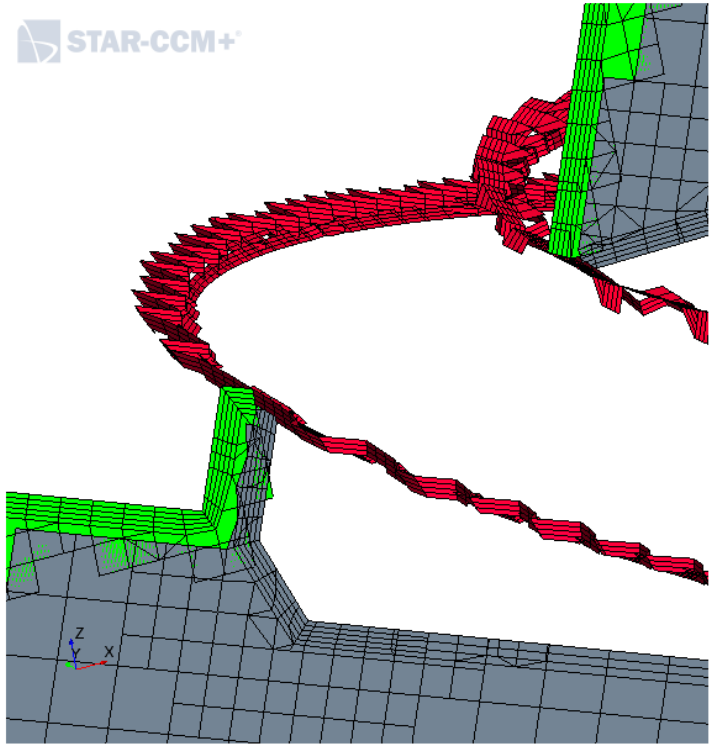


A gap will be created, if there are less than 2-4 cells between two wall boundaries

Mesh

Mesh motion

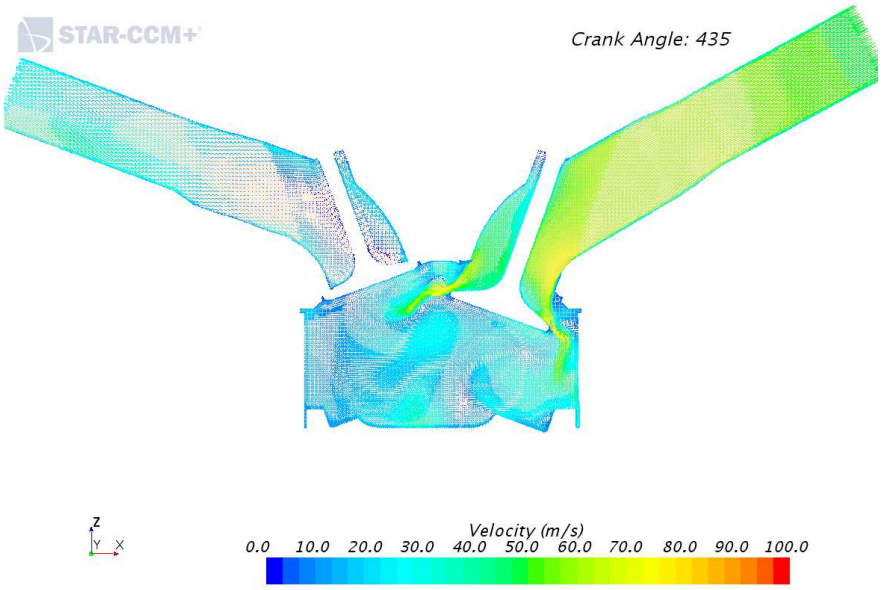


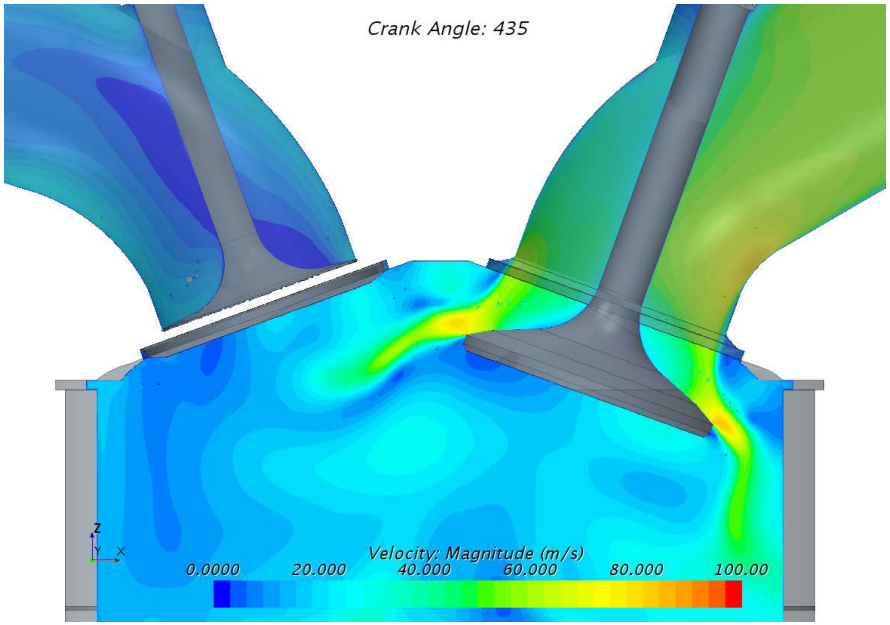


ZeroGap wall

Physics

- **Physics**
  - Implicit unsteady
  - Ideal gas
  - Segregated flow solver
  - Realizable k-epsilon two-layer
- **Boundaries**
  - Stagnation inlet (unrealistic)
  - Pressure outlet (unrealistic)
- **Motion**
  - Engine RPM 3600
  - Piston, intake/exhaust valve:
    User Defined Vertex Motion
- **Overset interfaces**
  - Close proximity enabled
  - Alternate hole cutting enabled
  - Interpolation: distance weighted





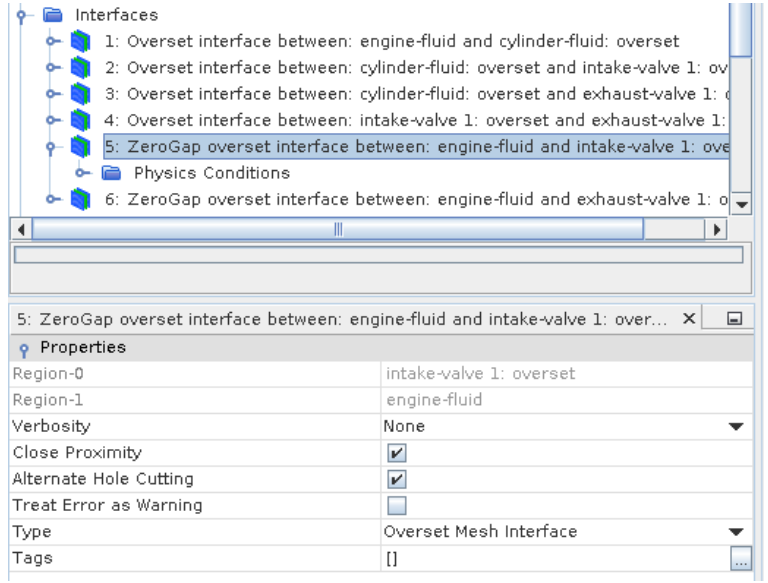
Overset features

Close Proximity

- cell is deactivated only when the cell centroid is outside the boundary

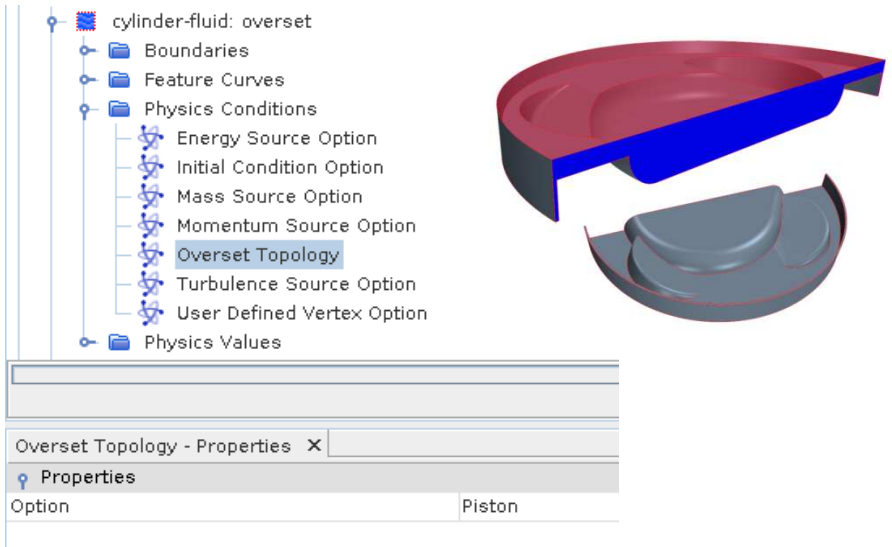
Alternate Hole Cutting

- determines whether the global or the layered hole-cutting approach is used

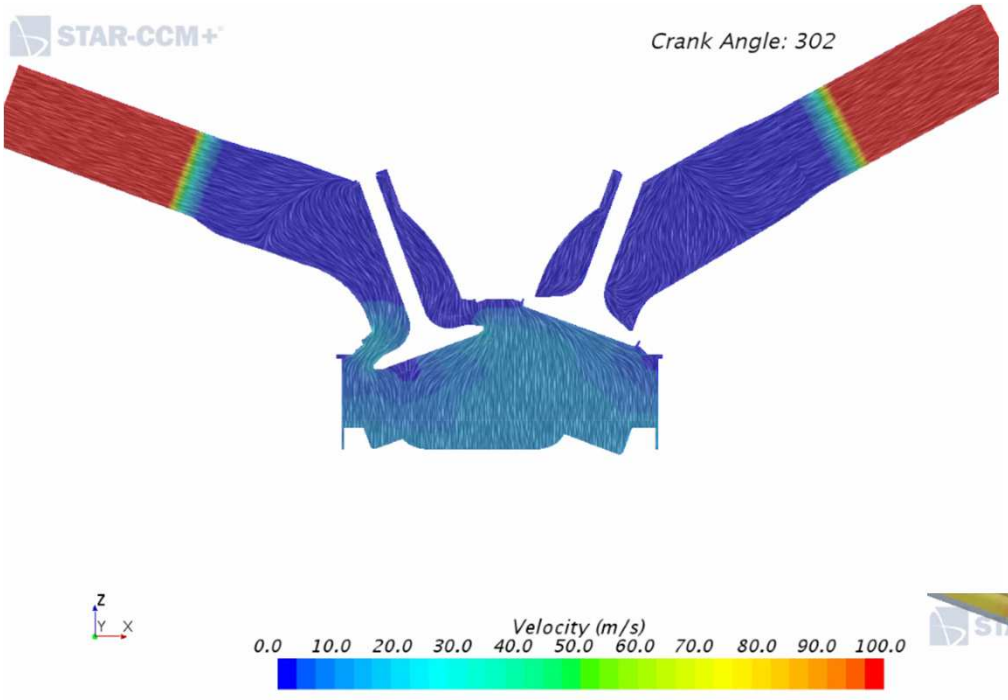


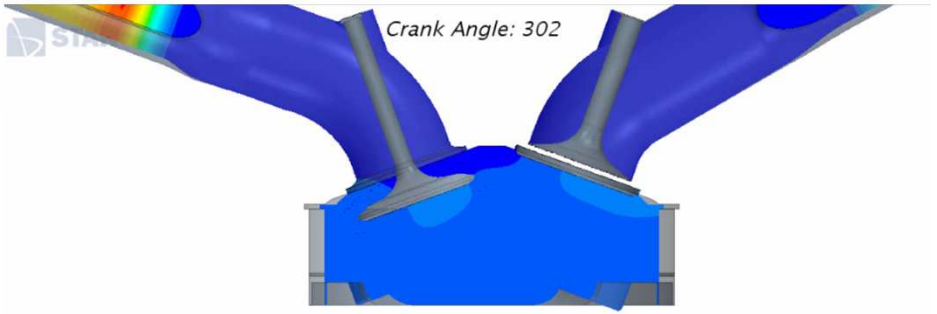
Overset topology: Piston

- for applications where a piston moves within a cylinder. The cells underneath the piston are deactivated

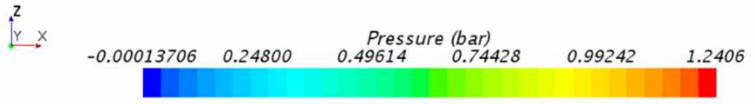


Post-processing





Note: This is a generic geometry. We do not apply realistic boundary conditions.



Thank you!

Questions?